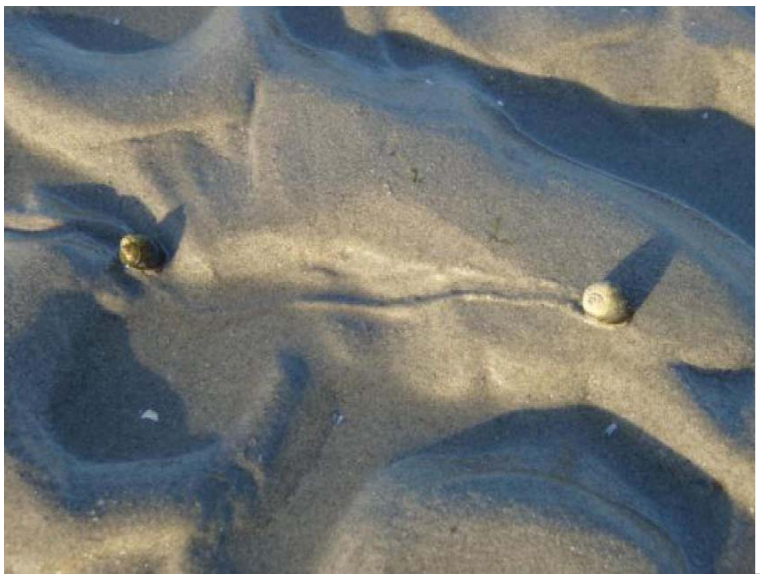
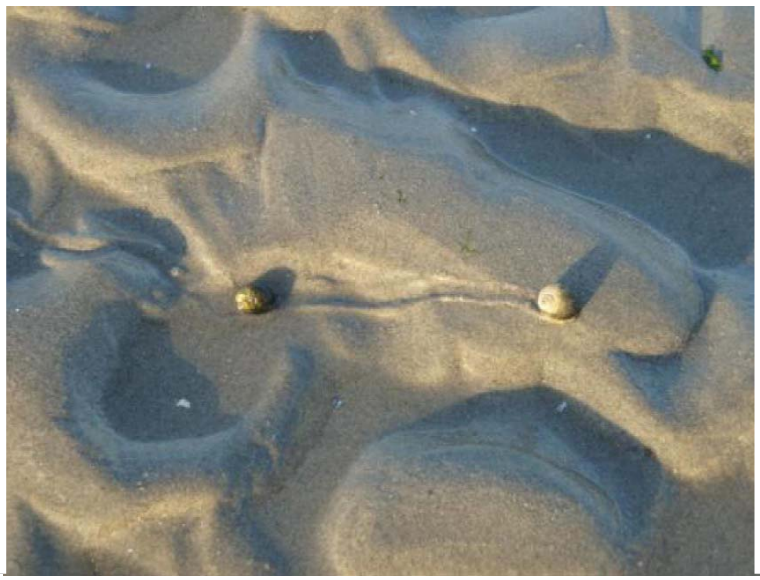
NAVIGATION IN DISORIENTED WAVE-DISLODGED PERIWINKLES:

The question of cue

Intertidal rocky shores are amongst the harshest and most extreme environments for the survival of their inhabitants. During emersion, a wide range of invertebrates such as gastropods often reach the edge of their thermal tolerance which mainly leads them to aggregate and to seek refuge into crevices, pits or pools. However, breaking waves are another, though still widely overlooked, source of snail stress through dislodgement that might displace individuals in unsuitable habitats, and ultimately reduce their survival. A critical issue for gastropod ecology in the high hydrodynamic intertidal area is then to understand the ability to navigate towards an appropriate habitat following dislodgement and the role played by water and air-borne chemicals. Although homing behaviour is a common feature among limpets, periwinkles such as *Littorina keenae* and *L. littorea* have only been shown to navigate towards the same shore level as their previous environment or to exhibit orientated movements due to geotaxis or phototaxis. Chemoreception has also been assumed to affect many aspects of snail behaviour. Particularly, water-chemical substances diffusing from a source or moving within odour plumes may be detected by the snails and hence, play an essential role in mating, feeding and avoidance behaviours. Additionally, chemicals embedded into snails' mucous deposits are highly involved in the now well documented trail following behaviour (i.e. the ability to follow the mucous trails laid down the substrate), which mainly directs the homing behaviour.

Here, we investigated the potential for *Littorina littorea*, a common periwinkle in north- western Europe, to navigate towards a specific location in the high intertidal following simulated dislodgement that led to displacements a few centimetres to 2 metres away from





their original substrate, an oblong rock (60 cm long, 30 cm wide and 40 cm high) isolated on a sandy flat, 5 m away from a rocky platform and exposed to wave breaking at high tide. Four experiments were designed to eliminate hierarchically the cues likely to influence *L. littorea* navigation. Firstly, we dislodged and relocated snails without manipulating either the rock or the surrounding sand. Second, we removed the odours related to food sources and conspecifics inhabiting the rock. Third, we eliminated the mucous trails and laid down the sand to finally wipe out both rock- and sand-borne odours. There was a 2-fold and 4-fold decrease in the numbers of individuals returning to the rock in the absence of chemical substances from the rock and sand, respectively. Finally, the 19-fold decrease in the return rate of individuals in the absence of both cues suggests a strong synergistic effect on *L. littorea* navigation. This indicates that chemoreception is highly involved in the navigation, thus the survival, of the periwinkle *L. littorea* following wave dislodgement, but also that this species has the ability to exploit a variety of chemical cues which clearly have a multiplicative effect on their ability to find a suitable habitat.

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